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UC-41 – Health and Safety

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APPLIED HEALTH PHYSICS

ANNUAL REPORT FOR 1960

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OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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HEALTH PHYSICS DIVISION

APPLIED HEALTH PHYSICS ANNUAL REPORT FOR 1960

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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UNION CARBIDE CORPORATION
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U. S. ATOMIC ENERGY COMMISSION

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I. SUMMARY

Although there were the usual fluctuations in background at certain of the monitoring stations, the contamination levels recorded do not differ significantly from those of the previous year except that there appears to be a slight trend downward. This downward trend can be attributed to a curtailment of operations at the Laboratory, the gradual implementation of the containment program, and a curtailment in world-wide weapons testing.

Two personnel exposures were recorded which have been reported elsewhere. One employee received a relatively high exposure to the left hand which consisted primarily of soft radiation. A second employee apparently has accumulated a sizeable fraction of a permissible body burden of Pu^{239}.

The number of unusual occurrences increased over the previous year. However, in general, these events posed only routine problems and it is probable that the noted increase in such occurrences is due primarily to a more complete reporting system which was inaugurated early in the year.

A. Area Monitoring

The average air contamination level as shown by the continuous air monitors was 0.04% of the maximum permissible concentration for the Laboratory area and 0.1% for both the perimeter and remote areas[1]. These levels are approximately 1/10 of the 1959 values for the Laboratory area and 1/15 of the 1959 values for the perimeter and remote areas. The decrease in contamination levels may be attributed to the decrease in fall-out from weapons tests in the case of the perimeter and remote areas and to the drastic curtailment of Laboratory operations during the first half of 1960 in the case of the Laboratory area.

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1. The $(MPC)_a$ for occupational exposure is taken to be 1×10^{-9} $\mu c/cc$; the $(MPC)_a$ for the neighborhood population is taken to be 1/10 of the occupational exposure. (See NBS Handbook 69, Table 4, p. 94.)

The peak value of air contamination on the Laboratory area, which occurred during Week No. 45, (Fig. 1) was due to a localized source and was limited to a relatively small area affecting only one monitoring station. Somewhat smaller peaks were observed as originating from the same localized source during Weeks 48 and 50.

Fall-out and rain water data generally followed the same downward trend during 1960 as the continuous air monitoring data. The peak levels shown early in 1960 during Weeks 8 and 9 (Figs. 4 and 5) appear to have resulted from weapons tests carried out reportedly by the French at a testing station in North Africa. (The ORNL data correlates well with unconfirmed reports received locally concerning the fall-out pattern expected on the North American Continent as a result of the North Africa tests.) The peak during Week 36 (Fig. 3) was caused by the presence of a single particle of Ru^{106} of undetermined origin. During Week 48 the number of particles collected at the Laboratory area and at the perimeter stations increased by factors of 12 and 22 respectively. The increase was attributed to faulty filters located at the off-gas stack units.

Assuming uniform mixing of the White Oak Creek effluent with the waters of the Clinch River, the average concentration of mixed fission products in the Clinch River at Mile 20.8 (juncture of White Oak Creek with the Clinch) and at Mile 4.5 (near Kingston, Tennessee) were 24.4% and 13.3% respectively of the maximum permissible concentration[2]. The $(MPC)_w$ value was exceeded during two weekly sampling intervals during the year. These instances occurred during Weeks 45 and 46 (Fig. 6) when the flow from Norris Dam was curtailed to permit repairs on the apron of the dam.

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2. The percentages noted represent the permissible concentration for the particular mixture of radionuclides which were present and the values used are those which apply to the neighborhood population of a controlled area as defined by the NCRP.

Silt monitoring[3] performed during the summer showed the gamma count rate in the Clinch River to be essentially the same as in 1959 with the point of maximum count shifting downstream from Mile 16.3 in 1959 to Mile 11.0 in 1960. The gamma count rate in Tennessee River silt showed an increase in all reservoirs studied except the Hales Bar reservoir. The Hales Bar reservoir is relatively short (approximately 40 miles long), narrow, and almost always has considerable flow resulting in more scouring than in the case of other reservoirs included in the survey. The contaminated silt in the Tennessee River system seems to be working its way downstream from one reservoir to the next with the passage of time. The survey planned for the summer of 1961 will be extended to the mouth of the Tennessee River in order to obtain a better evaluation of this apparent "migration" phenomenon.

The total number of curies released to the Clinch River in 1960 was 2186 as compared to 937 during 1959. This twofold increase was due primarily to seepage of Ru^{106} from the waste pits. Radiochemical analyses of White Oak Lake effluent show that Ru^{106} accounted for about 78% of the radioactive content in 1960 as compared to 47% in 1959. The percentage of Sr^{90} decreased from 7.6 in 1959 to 2.5 in 1960. As the relative hazard of Ru^{106} is low compared to Sr^{90}, the per cent $(MPC)_w$ in the river was not significantly affected by the increase in the curie content of contamination released.

The average radiation background in the Laboratory area, as based on monthly measurements, was 0.13 mr/hr. The average background measured in the perimeter area was 0.015 mr/hr. These may be compared to the average background values established in 1943 of 0.012 mr/hr.

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3. Procedures and techniques described in ORNL-2847 ("Radioactivity in Silt of Clinch and Tennessee Rivers", by W. D. Cottrell).

Modification of the gates at White Oak Dam was completed in April. The change allows for a fixed position of the lower gate which results in the creation of a small permanent lake behind White Oak Dam at an elevation of a few inches above Watts Bar reservoir. The change was undertaken in order to allow free flow through the dam permitting relatively precise flow measurements accompanied by relatively accurate proportional sampling. (Precise flow measurements have not been possible at the dam during certain periods of flow since the lake was drained in 1955 because of the influence of backwater from the Watts Bar impoundment.)

An improved water monitor designed by the Instruments and Controls Division has been installed at White Oak Dam. Data generated by the equipment are telemetered directly to area monitoring headquarters for processing.

B. Personnel Monitoring

During 1960 one employee received a hand exposure which exceeded the values recommended in NBS Handbook 59. The exposure consisted primarily of beta radiation which resulted in an estimated skin dose to the hand of approximately 5500 rem[4]. The highest whole body external dose sustained by an employee was about 6 rem or 50% of the maximum permissible annual dose. Only 5 employees received external exposures greater than the maximum permissible yearly average of 5 rem.

During the period of this report, urine data accrued from one employee was such as to indicate that a body burden of 50% ± 25% of the maximum permissible level may have been sustained as the result of work with Pu^{239}. The employee has been assigned to other work.

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4. See Appendix I.

As of December 25, 1960, the highest cumulative dose sustained at ORNL was 74.4 rem. The ten highest cumulative doses sustained at ORNL ranged downward from the high of 74.4 rem to 55.9 rem.

As of December 25, 1960, only one individual had accumulated a total dose which exceeded the age proration formula, 5(N-18). The major portion of this dose resulted from an accident which occurred during 1957 and, at the end of 1960, represented 169% of the dose permitted by the formula 5(N-18).

About 10% of the 612,132 garments handled by the Laundry Monitoring Unit were found to be above maximum permissible limits. In addition to the above items, a total of 873,238 items which included towels, shoe covers, and caps passed through the monitoring facility.

C. Assays

A total of 658,271 samples were processed through the counting room for an average of 12,659 samples per week. This represents an increase of about 61% over 1959 and includes approximately twice the number of samples that were processed during 1958.

The Bio-Assays Unit processed a total of 4717 samples which is an increase of 68% over 1959. Approximately one-half of the samples were analyzed for gross alpha and about one-fourth were analyzed for strontium.

The use of electronic data processing equipment for bio-assay analysis began during 1960 and reports were issued on a monthly cumulative basis; thus, the December summary for 1960 covers the full 12-month period and constitutes a detailed annual report for bio-assay analysis.

Several bio-assay procedures were developed or modified to meet the needs of an expanded and more versatile internal dosimetry program.

Urine analysis procedures evaluated or adopted during the year include:

Total Rare Earths (TRE) - a double precipitation procedure, now in routine use;

Co^{60} - an ion exchange method, in occasional use;

Ru^{106} - a distillation technique, adapted from that reported in the Master Analytical Manual;

As^{74} - A combination distillation-precipitation procedure, in occasional use;

Pu - The method now in use at LASL has been used increasingly except for the radioautography, which will be included during the next report period;

Th^{232} - A method for determination by radioactivation is currently being studied with preliminary indications of detection of millimicrogram quantities.

A single channel gamma spectrum analyzer has been made available for analysis of Na^{24} in blood serum.

The operation of the Whole Body Counting Facility became the responsibility of the Health Physics Technology Section during 1960. Internal dose determinations resulting from the "whole body counting" technique will be included in the personnel monitoring section of this report.

D. Instrumentation

The Design Section of the I and C Division has continued a cooperative program with Applied Health Physics for development and design of instruments for Health Physics application. The work this year included:

1. Fabrication and testing of a preliminary-design monitor for air-borne plutonium particulates. An instrument of this type would warn of plutonium concentrations of 2 x $(MPC)_a$ within 4 hours and of higher

concentrations in proportionately lesser time intervals. The project for this instrument has been concluded.

2. A transistorized circuit, rechargeable battery GM Survey Meter, which will not "block" in gamma radiation fields as great as 100 r/hr, has been prototyped, tested, and approved. The model designation is ORNL Q-2092.

3. A single unit, transistorized circuit, rechargeable battery thermal neutron survey meter, Model ORNL Q-2004, has been prototyped, tested, and approved. The detector consists of a BF_3 counter and the upper limits of the rate meter ranges are 200, 2000, and 20,000 thermal neutrons per cm^2 per second.

4. Two A.C. operated count rate meter models have been designed, tested, and approved. One model, ORNL Q-2091, is a compact, semi-portable unit weighing 20 pounds which makes use of a panel meter, alarm relay, input from GM Counter or alpha scintillation probe, audible speaker, and outputs for strip chart recorders. The second model, ORNL Q-2191, is similar to the above model except that it is adapted for standard rack monitoring and utilizes a one-milliamp recorder positioned in the front panel. The Q-2091 model is provided for low-level beta-gamma or alpha monitoring of work area, equipment, and personnel. The Q-2191 model can be used in conjunction with air monitoring and background monitoring equipment.

5. A scintillation detector probe for alpha particles, ORNL Q-2101, has been established as a stores stock item. The detector face (10 cm x 10 cm) has an effective area of 70 cm^2 and an average detection efficiency of 15% for the alpha particles associated with Pu^{239}. It can

be used with rate meters Q-2091 and Q-2191 as well as with the Q-1975 portable counters.

6. A filter-counter-shield assembly for beta-gamma air monitoring has been developed and subjected to initial testing. The unit, ORNL Q-2118, features a mechanism for changing filters automatically. The mechanism permits the filter to be changed on a pre-set time interval, when the counting rate exceeds a predetermined level, and/or on a signal activated manually either locally or remotely. The Q-2118 will be a standard component of the new model Q-2240 air monitor described below.

7. A complete new design for the ORNL CAM has been approved. The new model, Q-2240, incorporates the Q-2118 filter changer mechanism and the Q-2191 counting rate meter described earlier; a Roots-Connersville pump and an annunciator-alarm unit complete the system.

8. A transistorized, portable, single-channel analyzer with a NaI detector for aerial surveying has been in use for several months. The unit weighs 10 pounds and drives a portable one-milliamp recorder.

9. A transistorized, portable fast neutron survey meter designated as ORNL Q-2047 is undergoing tests.

E. Radiation Surveys

During 1960, the Laboratory sustained approximately 74 unusual occurrences of which only two were classified as major[5].

One of the two major events occurred when an employee sustained an overexposure while removing debris from a drain trough in a cell located in one of

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5. The method for classifying unusual occurrences is described in ORNL-3073, pp. 4-5.

the isotope production facilities[6]. The second event occurred when a quantity of radioactive dust was expelled from a hot cell and dispersed via the ventilation system throughout a facility operated by the Solid State Division. Most of the contamination was confined to the inside of the facility; however, it was necessary to discontinue operation temporarily while decontamination procedures were in effect.

The 72 minor events may be classified as follows:

1. Cases involving <u>only</u> the contamination of equipment and/or facilities followed by minor clean-up effort - 23
2. Cases involving <u>both</u> the contamination of personnel and equipment followed by minor work restrictions and/or clean-up effort - - - - -36
3. Cases involving <u>only</u> the contamination of personnel followed by minor work restrictions - 13

TOTAL 72

Responsibility for all 74 events has veen designated as follows:

Analytical Chemistry	3
Biology	2
Chemistry	2
Chemical Technology	13
Engineering and Mechanical	5
Electro-Nuclear Research	4
Health Physics	3
Instrumentation and Controls	1
Isotopes	13
Metallurgy	1
Neutron Physics	2
Operations	11
Reactor Division	11
Solid State	3
TOTAL	74

6. See Appendix I.

Of the 74 events only 12 occurred (or were detected) during the off shifts when Laboratory occupancy was relatively low.

II. STATISTICAL RESUME

A. Area Monitoring

B. Personnel Monitoring

Table 7 Pertinent Data Regarding the Ten Laboratory Employees Who Have Sustained the Highest Cumulative Dose of Penetrating Radiation as of December 25, 1960.

Table 8 Pertinent Data Regarding the Ten Laboratory Employees Who Have Sustained the Highest Exposure as Based on the Age Formula 5(N-18).

Table 9 Dose Data Summary for Laboratory Population Involving Exposure to Penetrating Radiation during 1960.

Table 10 Dose Data Summary for Laboratory Population as of December 25, 1960, Involving Cumulative Exposure to Penetrating Radiation as Based on the Age Proration Formula 5(N-18).

Table 11 Personnel Meter Distribution and Performance Data.

C. Assays

Table 12 Counting Services Performed, 1960.

Table 13 Bio-Assays Analyses, 1960.

D. Instrumentation

Table 14 Instruments Acquired, 1960.

Table 15 Portable Instruments on Assignment to Field Areas by Building Number, 1960.

Table 16 Calibrations Resume, 1960.

Table 17 Emergency Instruments, Clothing, and Other Equipment Procured and Installed in the Emergency Vehicle Assigned to the Calibration Unit.

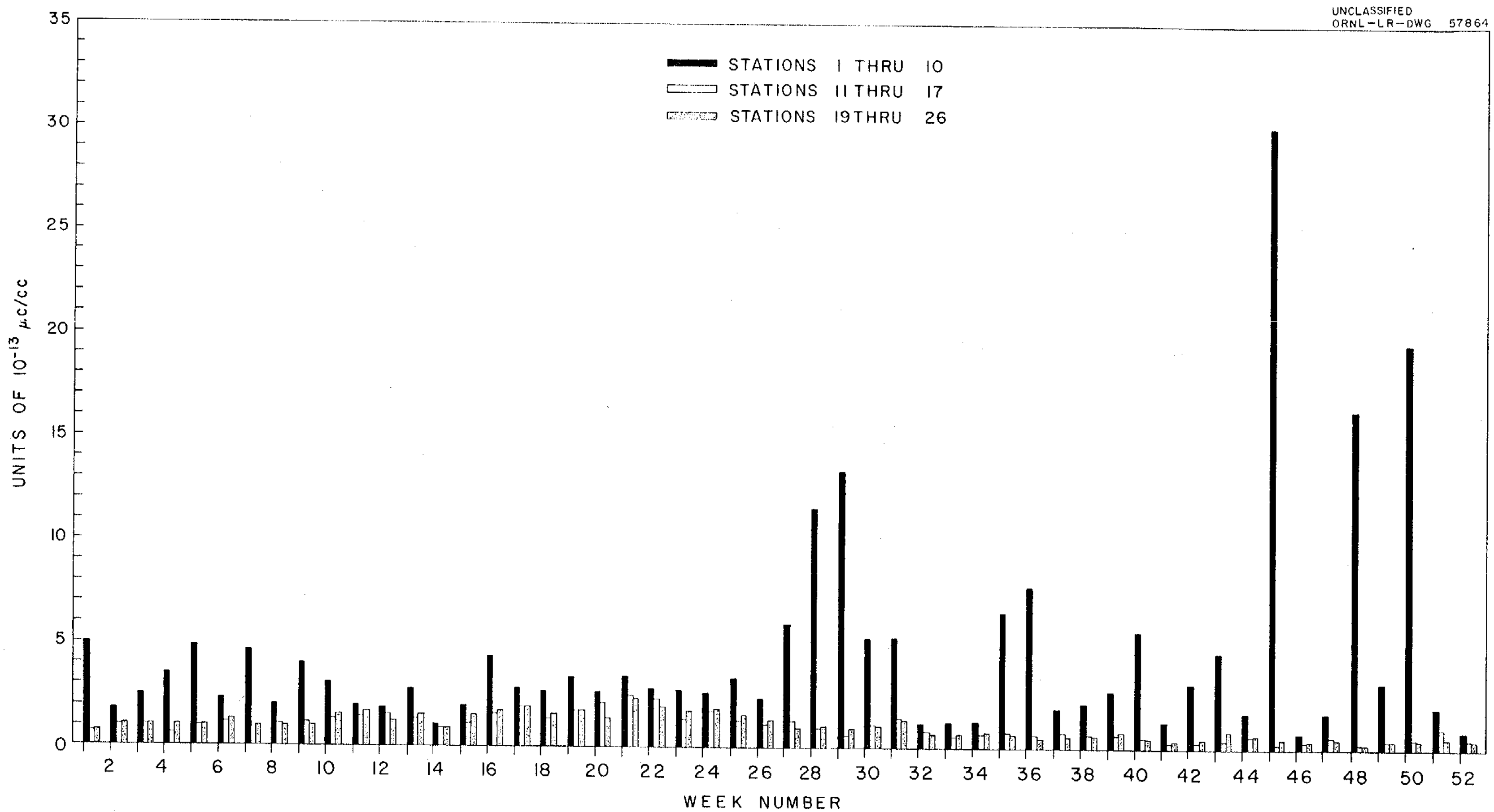

Fig. 1. Air Contamination Levels in 1960 as Measured on the Collecting Filters on the Continuous Air Monitors.

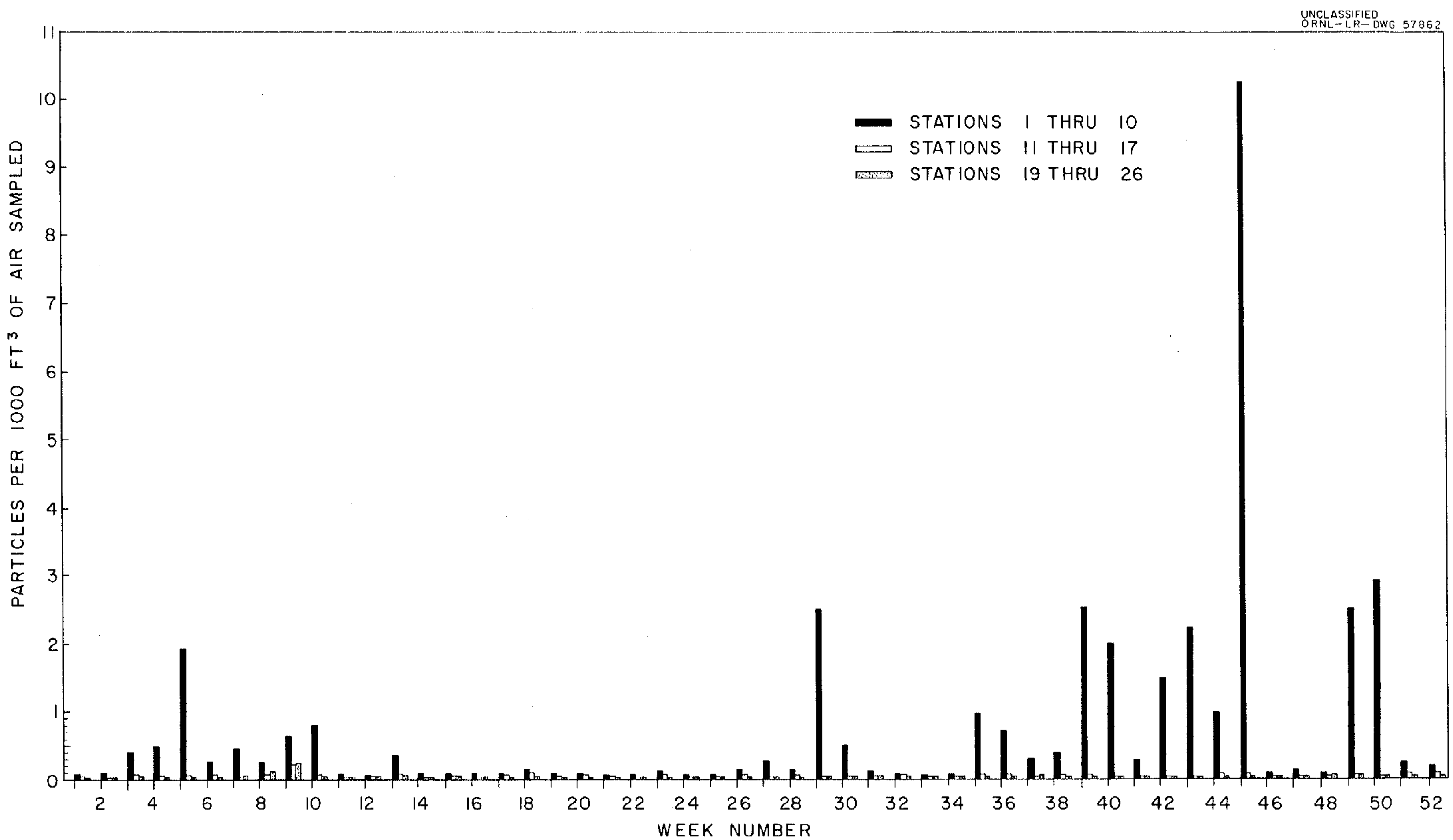

Fig. 2. Radioparticulate Fall-Out Collected on Filters by Continuous Air Monitors.

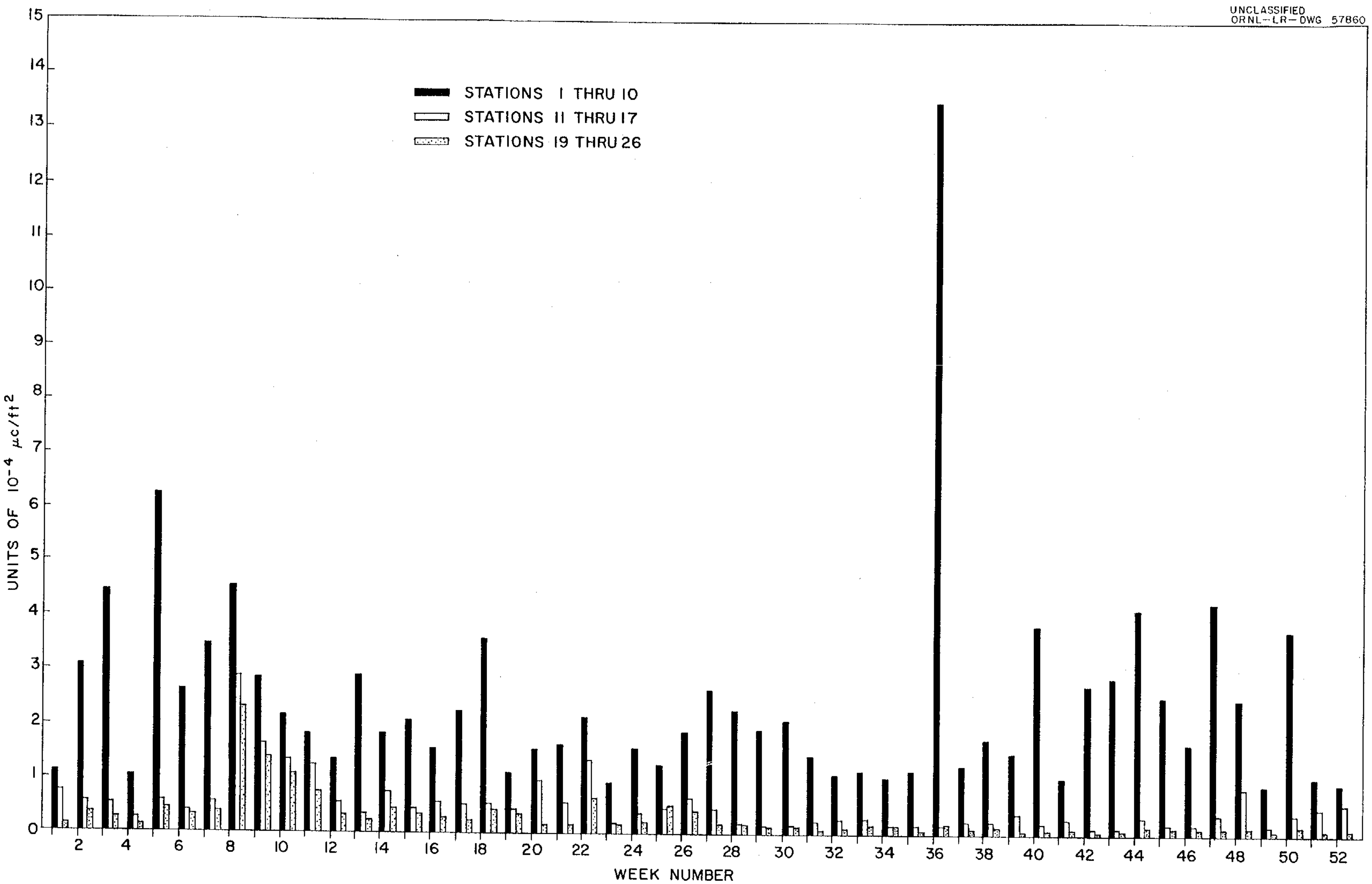

Fig. 3. Radioactive Fall-Out in 1960 as Measured by the Gummed Paper Method.

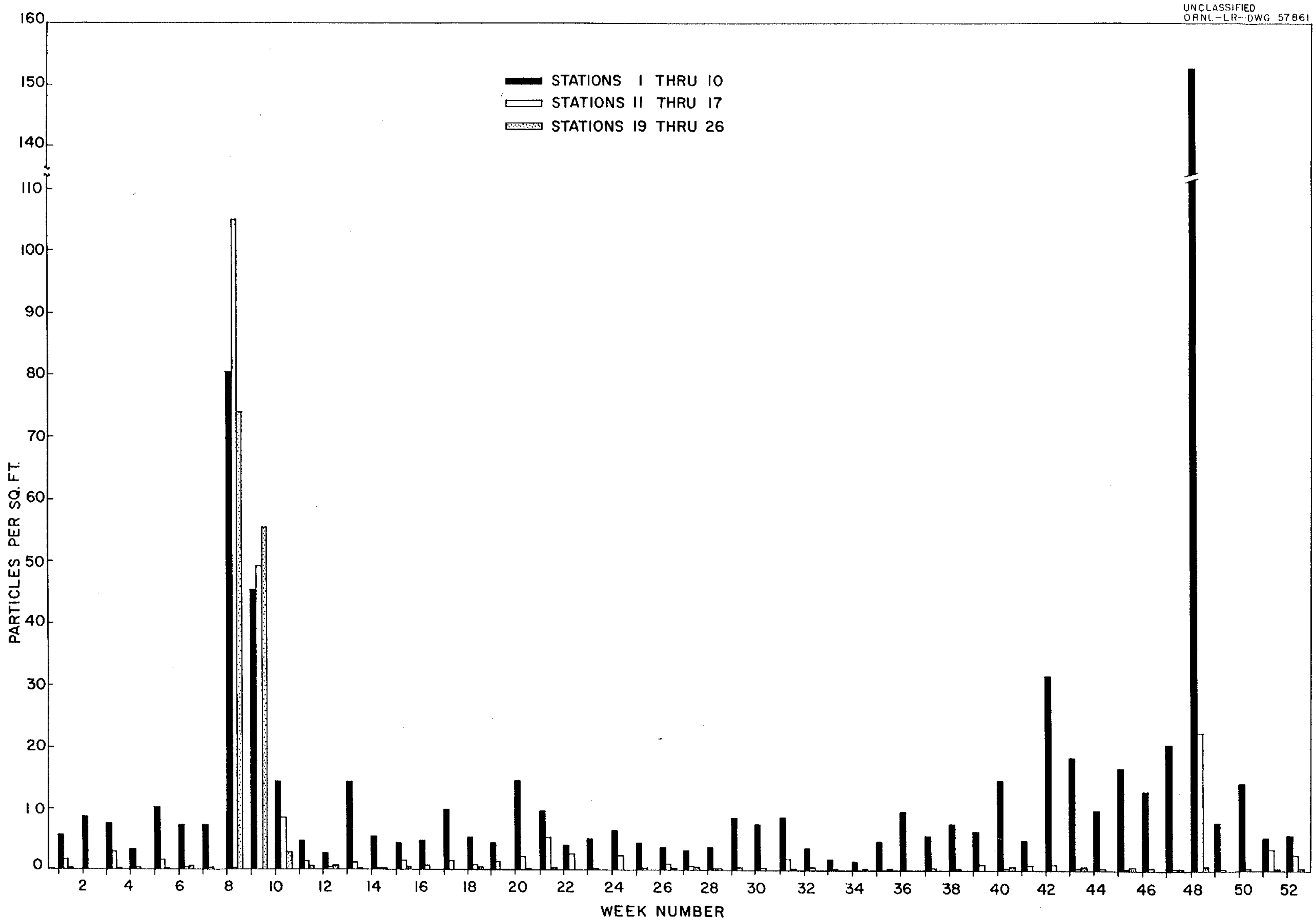

Fig. 4. Radioparticulate Fall-Out in 1960 as Measured by the Gummed Paper Method.

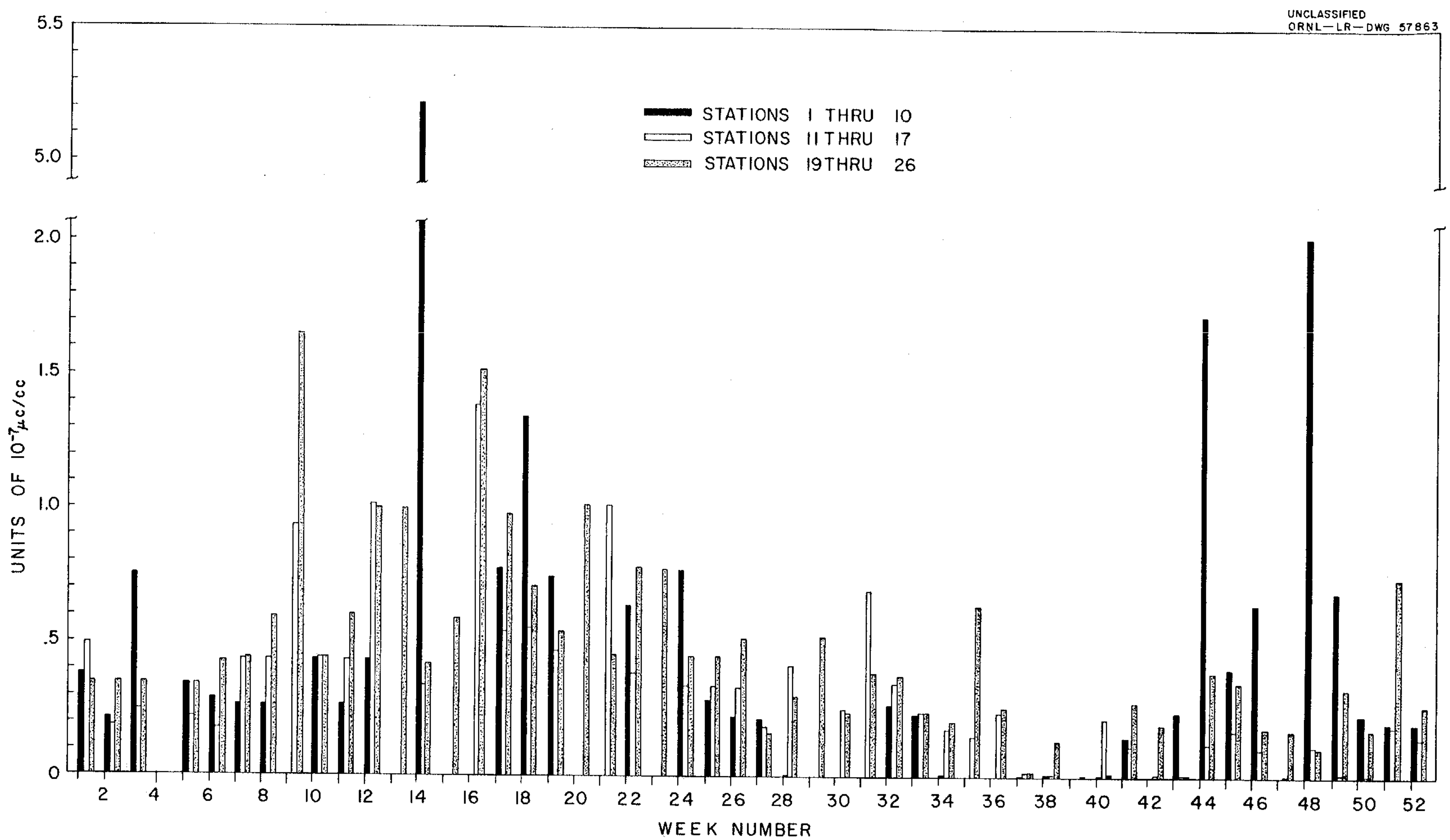

Fig. 5. Radioactivity in Rain Water in 1960.

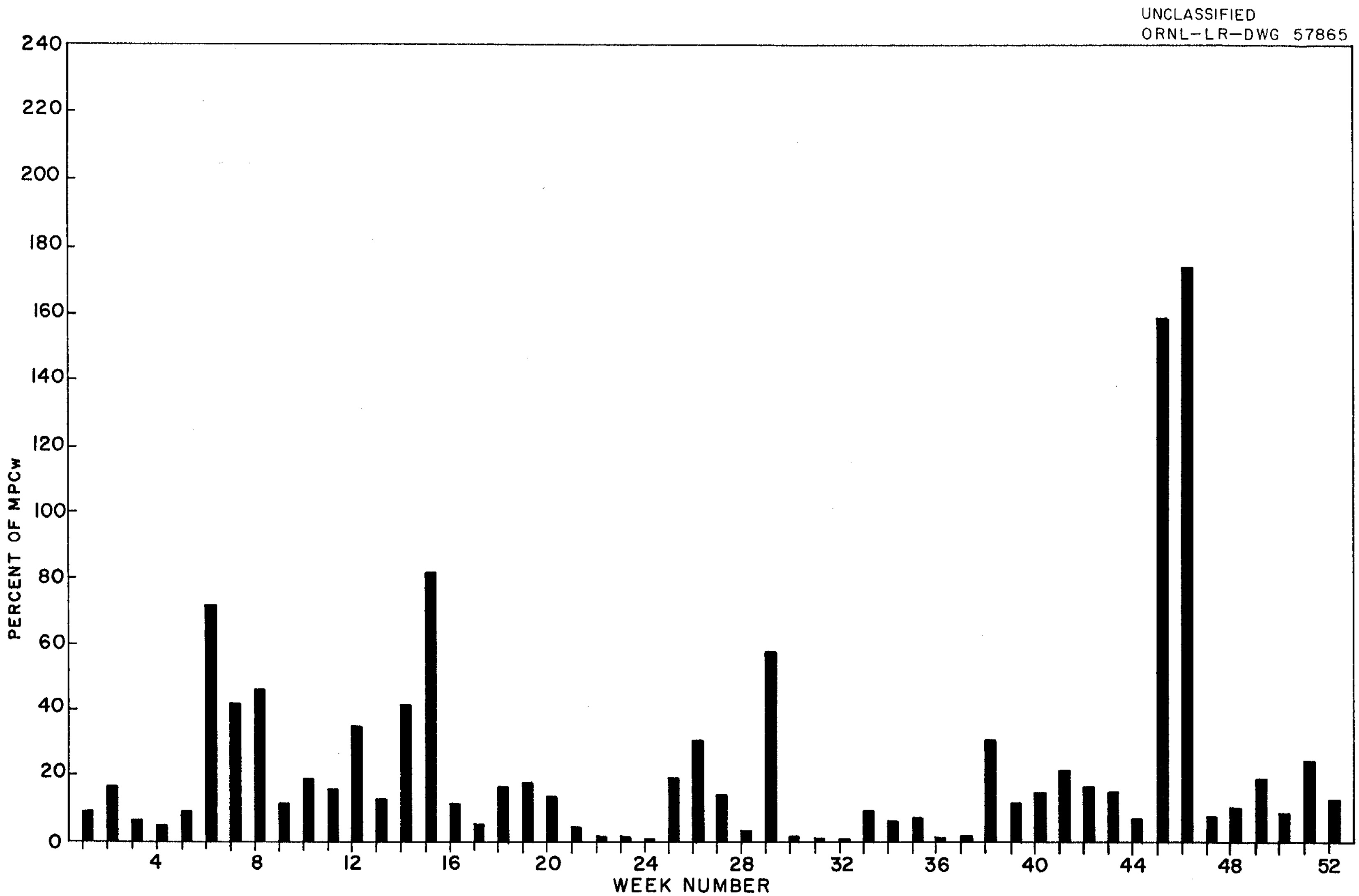

Fig. 6. Average Weekly Concentration of Radionuclides in the Clinch River During 1960 as Determined by Radiochemical Analyses.

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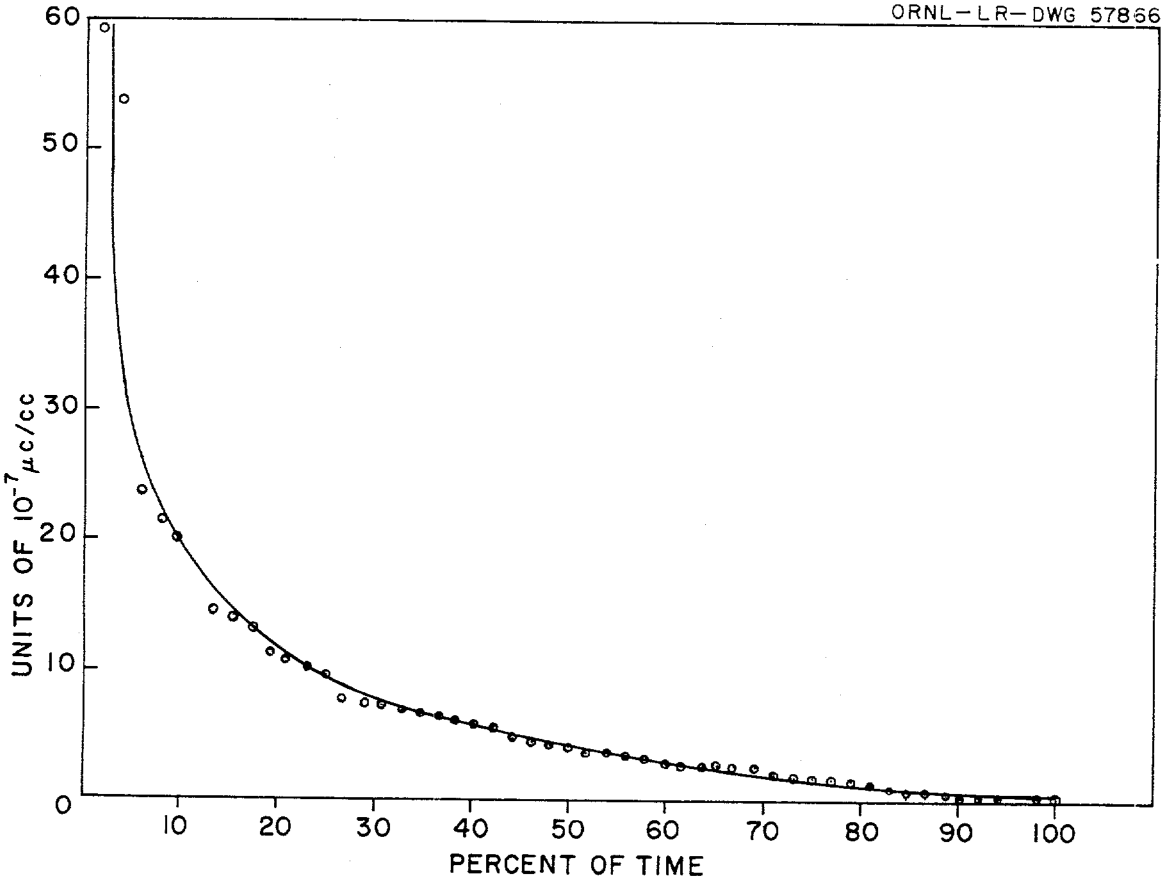

Fig. 7. Variations in the Concentrations of Radioactivity in the Clinch River 1960.

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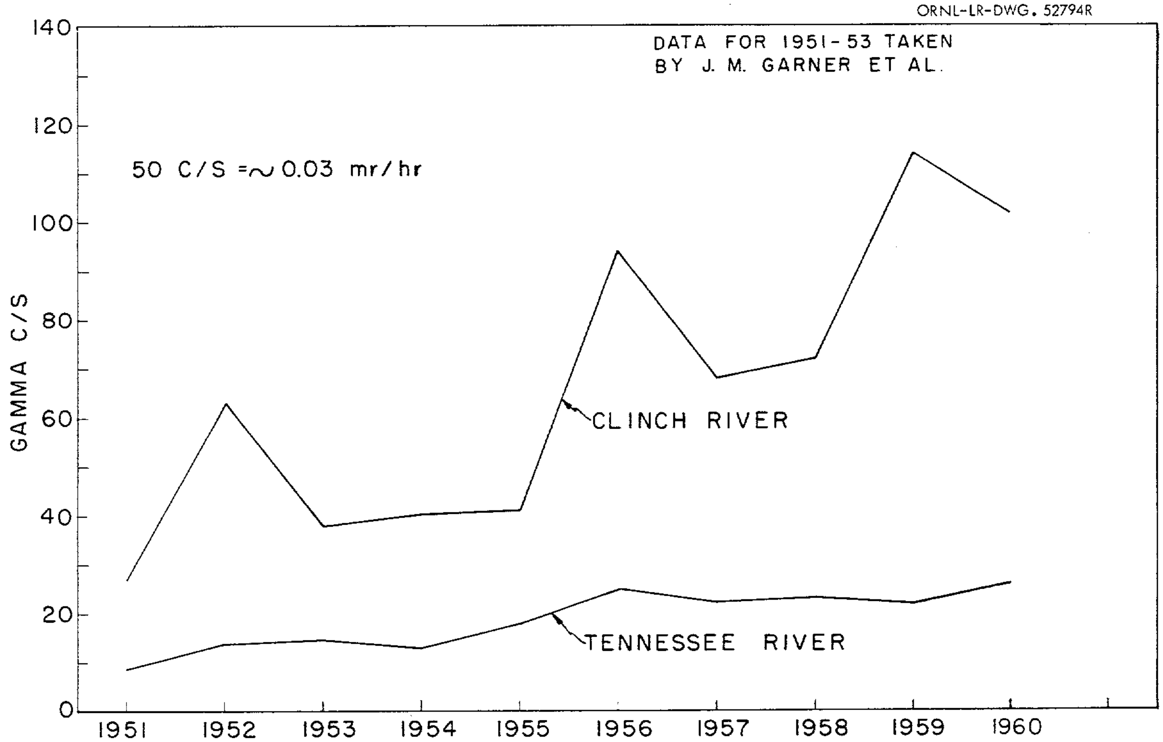

Fig. 8. Average Gamma Count at Surface of Silt Clinch and Tennessee Rivers 1951–60.

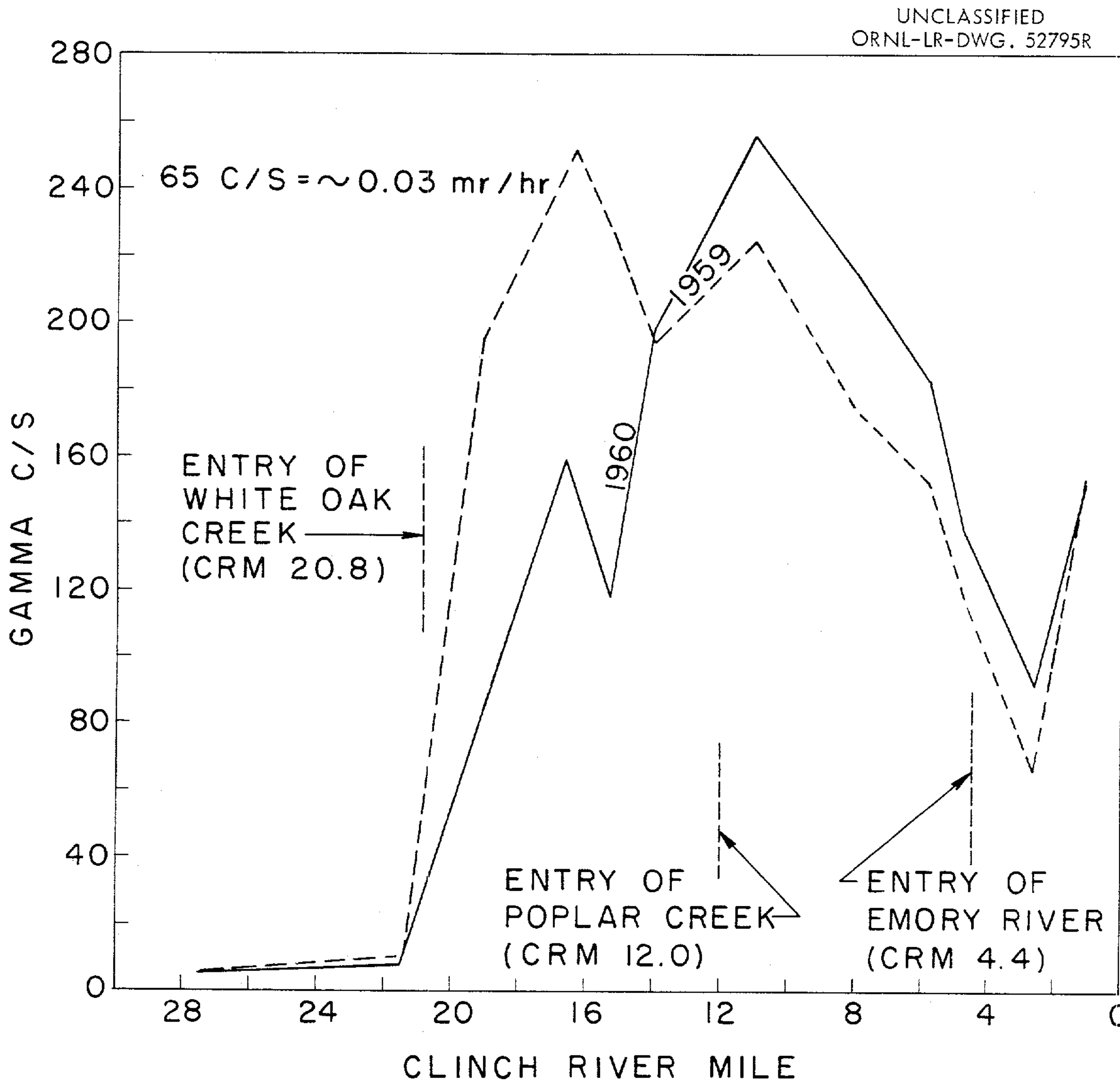

Fig. 9. Gamma Count at Surface of Clinch River Silt.

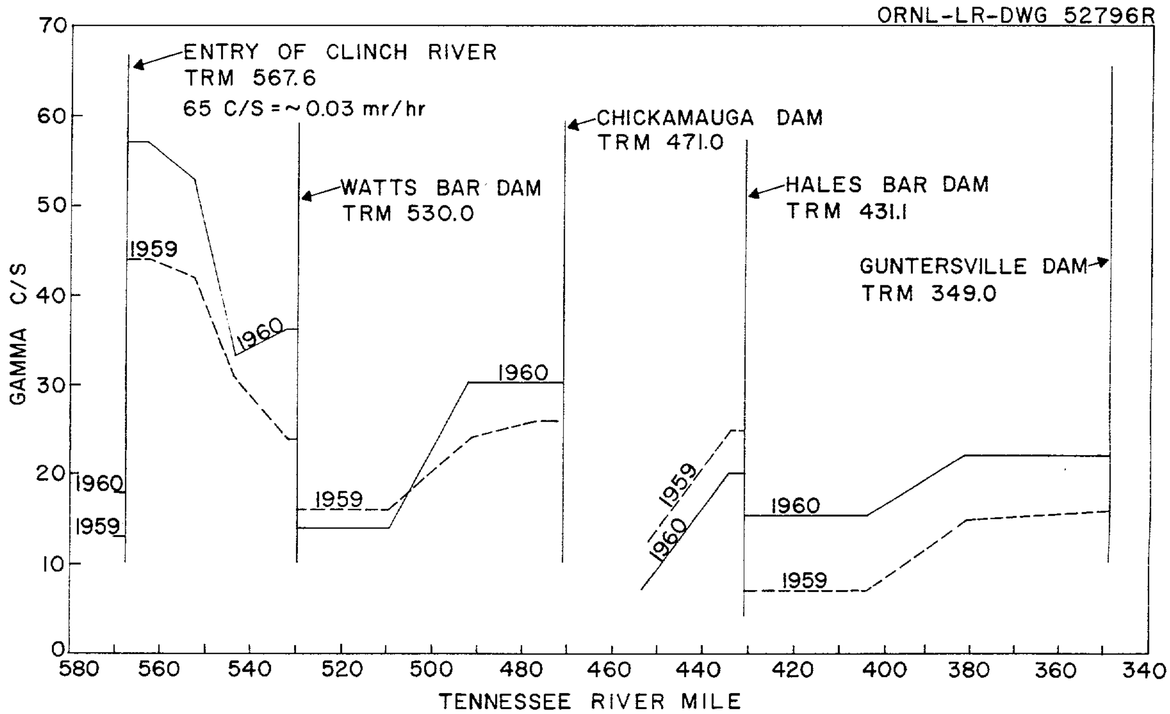

Fig. 10. Gamma Count at Surface of Tennessee River Silt.

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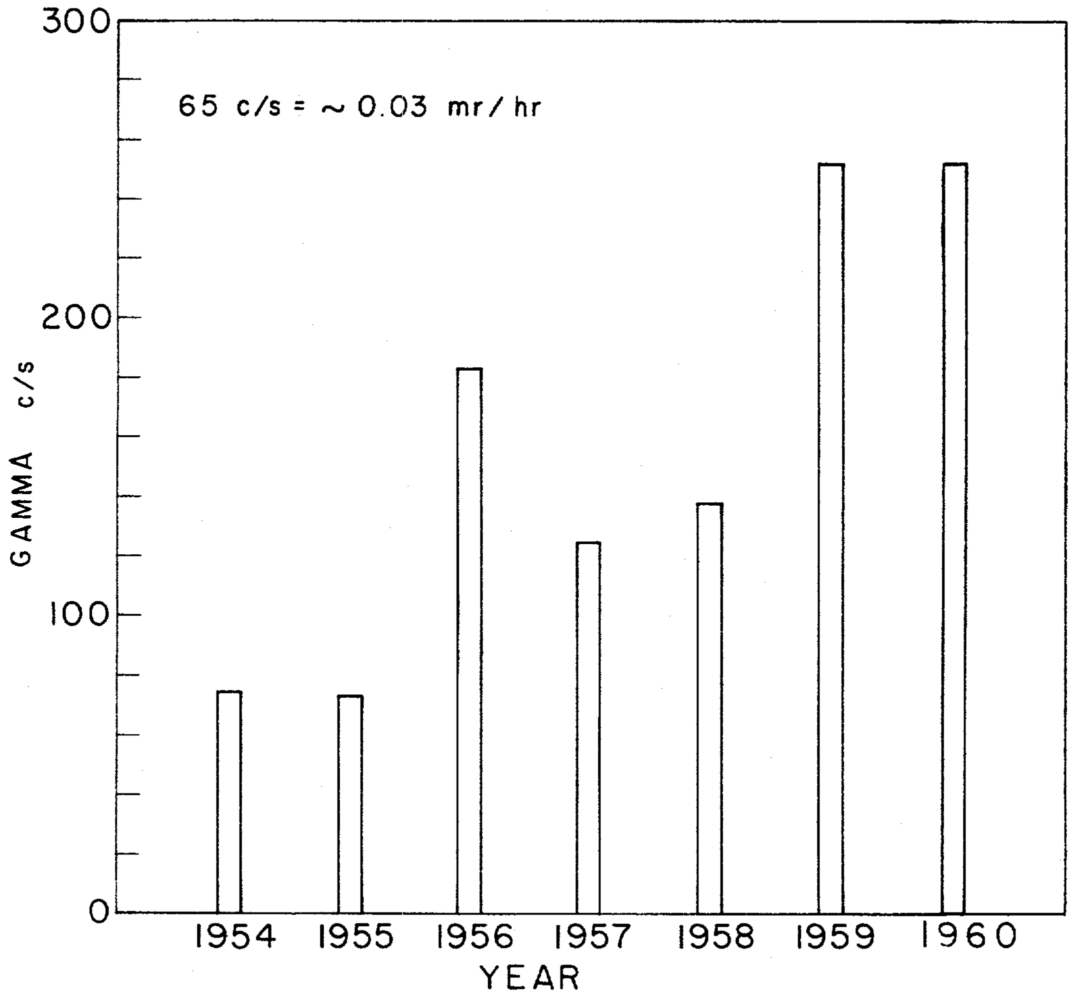

Fig. 11. Average Reading Across the Traverse at Location of Maximum Contamination.

Table 1

AVERAGE CONCENTRATION OF RADIOACTIVE MATERIALS IN THE CLINCH RIVER, 1960

Location	Concentration of Nuclides of Primary Concern in Units of 10^{-8} μc/cc					Average Concentration of Total Radioactivity 10^{-8} μc/cc	$(MPC)_w$[a] 10^{-6} μc/cc	% of MPC
	Sr^{90}	Ce^{144}	Cs^{137}	$Ru^{103-106}$	Co^{60}			
Clinch River								
Mi. 37.5	0.08	0.07	*	*	*	0.25	0.31	0.69
Mi. 20.8[b]	0.72	0.42	0.63	22.0	1.30	76.5	3.14	24.4
Mi. 4.5	0.95	0.14	0.23	36.5	0.53	46.7	3.54	13.3

a Weighted average $(MPC)_w$ calculated for the mixture using $(MPC)_w$ values for specific radionuclides recommended in the NBS Handbook 69.

b Values given for this location are calculated values based on the levels of waste released and the dilution afforded by the river.

* None detected.

Table 2

AVERAGE WEEKLY AIR CONTAMINATION DATA BY STATIONS, 1960

Station Number	Location	Long-Lived Activity $\mu c/cc$	No. of Particles by Activity Ranges[a] $< 10^5$ d/24hrs	10^5-10^6 d/24hrs	10^6-10^7 d/24hrs	$> 10^7$ d/24hrs	Total	Particles Per 1000 ft^3
Laboratory Area								
HP-1	S 3587	1.63×10^{-13}	8.71	0.08	0.00	0.00	8.79	0.18
HP-2	S 3001	2.05	12.42	0.50	0.00	0.00	12.92	0.34
HP-3	S 1000	2.01	7.54	0.21	0.02	0.02	7.79	0.12
HP-4	W 3513	2.94	11.61	0.02	0.02	0.02	11.67	0.24
HP-5	E 2506	24.07	158.48	1.84	0.08	0.00	160.40	5.29
HP-6	SE 3012	2.05	15.44	0.42	0.02	0.00	15.88	0.27
HP-7	W 7001	1.59	2.75	0.15	0.00	0.00	2.90	0.05
HP-8	Rock Quarry	1.96	1.79	0.00	0.00	0.00	1.79	0.03
HP-9	N Bethel Valley Rd.	2.69	11.15	0.17	0.02	0.00	11.34	0.19
HP-10	E 2074	3.43	28.69	0.23	0.00	0.00	28.92	0.68
Average		4.49×10^{-13}	25.85	0.35	0.02	0.00	26.22	0.73
Perimeter Area								
HP-11	Kerr Hollow Gate	1.00×10^{-13}	0.92	0.00	0.00	0.00	0.92	0.02
HP-12	Midway Gate	1.11	1.45	0.00	0.02	0.00	1.47	0.03
HP-13	Gallaher Gate	0.89	0.48	0.04	0.00	0.00	0.52	0.01
HP-14	White Wing Gate	0.77	0.56	0.02	0.00	0.00	0.58	0.01
HP-15	Blair Gate	1.34	1.29	0.00	0.00	0.00	1.29	0.03
HP-16	Turnpike Gate	0.88	0.61	0.00	0.00	0.00	0.61	0.01
HP-17	Hickory Creek Bend	1.03	0.29	0.04	0.02	0.00	0.35	0.01
Average		1.00×10^{-13}	0.80	0.01	0.01	0.00	0.82	0.02
Remote Area								
HP-19	Norris Dam	1.16×10^{-13}	0.63	0.00	0.00	0.00	0.63	0.01
HP-20	Loudoun Dam	1.11	0.38	0.00	0.00	0.00	0.38	0.01
HP-21	Douglas Dam	0.98	0.38	0.06	0.00	0.00	0.44	0.01
HP-22	Cherokee Dam	1.00	0.81	0.00	0.00	0.00	0.81	0.01
HP-23	Watts Bar Dam	1.09	0.31	0.00	0.00	0.00	0.31	0.01
HP-24	Great Falls Dam	1.14	0.56	0.00	0.00	0.00	0.56	0.01
HP-25	Dale Hollow Dam	0.95	0.73	0.04	0.00	0.00	0.77	0.01
HP-26	Berea, Kentucky	0.67	0.41	0.00	0.00	0.00	0.41	0.01
Average		1.02×10^{-13}	0.52	0.01	0.00	0.00	0.53	0.01

a. Determined by continuous air monitor.

Table 3

AVERAGE WEEKLY FALLOUT DATA BY STATIONS, 1960

Station Number	Location	Long-Lived Activity $\mu c/ft^2$	No. of Particles by Activity Ranges $< 10^5$ d/24hrs	10^5-10^6 d/24hrs	10^6-10^7 d/24hrs	$> 10^7$ d/24hrs	Total Particles Per Sq. Ft.
Laboratory Area							
HP-1	S 3587	2.73×10^{-4}	12.71	1.35	0.23	0.02	14.31
HP-2	S 3001	8.31	16.85	0.76	0.46	0.12	18.19
HP-3	S 1000	1.14	8.06	0.11	0.04	0.00	8.21
HP-4	W 3513	2.47	7.86	0.75	0.06	0.00	8.67
HP-5	E 2506	3.06	21.92	1.00	0.12	0.06	23.10
HP-6	SE 3012	3.53	20.87	1.61	0.38	0.06	22.92
HP-7	W 7001	0.55	4.80	0.06	0.02	0.00	4.88
HP-8	Rock Quarry	0.45	6.30	0.73	0.10	0.02	7.15
HP-9	N Bethel Valley Rd.	0.91	5.77	0.21	0.02	0.00	6.00
HP-10	E 2074	4.08	18.71	1.33	0.23	0.10	20.37
Average		2.43×10^{-4}	12.06	0.79	0.15	0.03	13.03
Perimeter Area							
HP-11	Kerr Hollow Gate	0.46×10^{-4}	4.48	0.06	0.00	0.00	4.54
HP-12	Midway Gate	0.90	5.82	0.08	0.00	0.02	5.92
HP-13	Gallaher Gate	0.39	3.96	0.00	0.00	0.00	3.96
HP-14	White Wing Gate	0.38	4.11	0.04	0.00	0.00	4.15
HP-15	Blair Gate	0.61	3.38	0.10	0.00	0.04	3.52
HP-16	Turnpike Gate	0.55	3.90	0.04	0.02	0.00	3.96
HP-17	Hickory Creek Bend	0.32	4.42	0.12	0.00	0.00	4.54
Average		0.52×10^{-4}	4.30	0.06	0.00	0.01	4.37
Remote Area							
HP-19	Norris Dam	0.30×10^{-4}	3.60	0.00	0.00	0.00	3.60
HP-20	Loudoun Dam	0.29	3.11	0.22	0.00	0.00	3.33
HP-21	Douglas Dam	0.30	3.23	0.29	0.06	0.00	3.58
HP-22	Cherokee Dam	0.28	1.85	0.17	0.00	0.00	2.02
HP-23	Watts Bar Dam	0.27	3.07	0.12	0.04	0.00	3.23
HP-24	Great Falls Dam	0.28	1.65	0.35	0.00	0.00	2.00
HP-25	Dale Hollow Dam	0.31	2.42	0.18	0.04	0.00	2.64
HP-26	Berea, Kentucky	0.32	1.17	0.17	0.02	0.02	1.38
Average		0.29×10^{-4}	2.49	0.18	0.02	0.00	2.69

Table 4

AVERAGE WEEKLY RAINOUT DATA BY STATIONS, 1960

Station Number	Location	Activity in Collected Rain Water, μc/cc
	Laboratory Area	
HP-7	West 7001	0.58×10^{-7}
	Perimeter Area	
HP-11	Kerr Hollow Gate	0.31×10^{-7}
HP-12	Midway Gate	0.35
HP-13	Gallaher Gate	0.30
HP-14	White Wing Gate	0.25
HP-15	Blair Gate	0.33
HP-16	Turnpike Gate	0.36
HP-17	Hickory Creek Bend	0.32
Average		0.34×10^{-7}
	Remote Area	
HP-19	Norris Dam	0.58×10^{-7}
HP-20	Loudoun Dam	0.32
HP-21	Douglas Dam	0.52
HP-22	Cherokee Dam	0.39
HP-23	Watts Bar Dam	0.45
HP-24	Great Falls Dam	0.51
HP-25	Dale Hollow Dam	0.44
HP-26	Berea, Kentucky	0.61
Average		0.57×10^{-7}

Note: Total rainfall in 1960 was 45.47 inches, a deviation of -13.2 % from the normal rainfall of 52.38 inches.

Table 5

AVERAGE WEEKLY LIQUID WASTE DISCHARGE, 1960

Measurements	Settling Basin		White Oak Creek Dam	
	Year 1960	% Deviation from 1959 Weekly Average	Year 1960	% Deviation from 1959 Weekly Average
Beta Curies Discharged	0.92	-73.6	42.1	+133
Submersion Data				
Beta (mrep/hr)	0.088	-67.4	0.132	+144
Gamma (mrep/hr)	0.123	-32.0	0.165	+275
Total	0.211	-52.2	0.297	+200
Pu and other transuranic Alpha Emitters discharged				
(μg/cc)	624.8×10^{-9}	-94.4	224.2×10^{-8}	-84.7
(mg)	7.091	-96.8	58.357	-72.3

Note: The probable average concentration in the Clinch River below White Oak Creek is calculated to be 7.65×10^{-7} μc/cc, using as a dilution factor the ratio of White Oak Creek discharge to the flow of Clinch River. This is 148% greater than the 1959 weekly average.

Table 6

TOTAL SAMPLES PROCESSED BY THE ANALYTICAL UNITS, 1960

	Continuous Air Monitor Filters		Fallout Tray Gummed Paper		Rain Water Samples		Liquid-Effluent Samples			
	Total No.	Average Weekly	Total No.	Average Weekly	Total No.	Average Weekly	Gross Beta	Total Gamma Submersion	Pu	Complete Radiochemical Analyses
Local Stations	511	9.8	530	10.2	72	1.4				
Perimeter Stations	371	7.1	371	7.1	566	10.9				
Remote Stations	411	7.9	414	8.0	724	13.9				
Building CAM's	4190	80.6								
Stack Monitors										
Special	1298	25.0	465	8.9						
Settling Basin							1101	259	104	
White Oak Creek							969			
Melton Branch							972			
White Oak Dam							1247	364	104	12
Clinch River										8

Table 7 Pertinent Data Regarding The Ten Laboratory Employees Who Have Sustained The Highest Cumulative Dose of Penetrating Radiation as of December 25, 1960.

Employee	Department or Division	Age	Tenure of Employment (years)	Dose (rem)
A	Isotopes	41	16	74.4
B	E and M	26	8	67.5
C	Isotopes	42	13	67.0
D	Isotopes	54	16	62.8
E	Isotopes	53	15	61.0
F	Isotopes	36	17	60.9
G	Isotopes	35	14	52.9
H	Isotopes	29	9	52.8
I	Operations	42	17	51.5
J	Isotopes	41	9	51.1

Table 8 Pertinent Data Regarding The Ten Laboratory Employees Who Have Sustained The Highest Exposure as Based on The Age Formula 5(N-18). (Note: Employees A, B, E, G, H, and J are also listed in Table 7.)

Employee	Department or Division	Age	Tenure of Employment (years)	% MPAD 5(N-18)
A (B above)	E and M	26	8	168.8
B (H above)	Isotopes	29	9	95.9
C	Isotopes	30	11	72.2
D	Isotopes	32	8	67.9
E (F above)	Isotopes	36	17	67.6
F	Isotopes	33	10	65.4
G (A above)	Isotopes	41	16	64.7
H (G above)	Isotopes	35	14	62.2
I	Instruments	30	9	58.5
J (C above)	Isotopes	42	13	55.9

Table 9 Dose Data Summary for Laboratory Population Involving Exposure to Penetrating Radiation During 1960.

Dose Range (rem)	Number of Employees	Percentage of Population
1 or less	3975	93.7
2 or less	204	4.8
3 or less	35	0.82
4 or less	15	0.35
5 or less	9	0.21
6 or less	5	0.12
7 or less	0	0
8 or less	0	0
9 or less	0	0

Table 10 Dose Data Summary for Laboratory Population as of December 25, 1960, Involving Cumulative Exposure to Penetrating Radiation as Based on the Age Proration Formula 5(N-18)

Dose Range % 5(N-18)	Number of Employees	Percentage of Population
10 or less	4058	93.1
20 or less	191	4.4
30 or less	68	1.6
40 or less	24	0.6
50 or less	8	0.2
60 or less	2	0.0
70 or less	5	0.1
80 or less	1	0.0
90 or less	0	0.0
100 or less	1	0.0
169 or less	1	0.0

Table 11

PERSONNEL METER DISTRIBUTION AND PERFORMANCE DATA

a. Pocket Meters

(1)	Meters Distributed	305365
(2)	Readable Meters	305228
(3)	Non-readable Meters	137
(4)	Non-readable Pairs	0
(5)	Off-scale Readings	1602
(6)	Off-scale Pairs	171

b. Film Meters

(1) Distribution and Processing Data

(a)	Film badge meters (routine)	22431
(b)	Film badge meters (non-routine)	296
(c)	Film meters (paper)	35522
(d)	Rings, packets, etc.	6229
(e)	Neutron film (routine)	20465
(f)	Neutron film (special)	682
(g)	Other installations	2521
(h)	Calibrations	5655
(i)	Total films handled	93801

(2) Reasons for Non-routine Processes

(a)	Special requests	125
(b)	Pocket meter total 1500 mr	0
(c)	Off-scale pocket meters	171
(d)	Total	296

(3) Data Loss

(a)	Film damaged (weathered, etc.) (complete data loss)	28
(b)	Film damaged (partial data loss)	6
(c)	Light, X-ray, etc. (complete data loss)	23
(d)	Light, etc. (partial data loss)	14
(e)	Badge meters not services	114
(f)	Films lost	53
(g)	Total	238

Table 12

COUNTING SERVICES PERFORMED, 1960

Type of Sample	Calculations	Number of Samples Alpha	Number of Samples Beta	Total	Weekly Average
Smears		289635	253559	543194	10446.0
Air Samples	35311	37310	36146	108767	2091.6
Area Monitoring		533	3991	4524	87.0
Sanitary Engineering		523	933	1456	28.0
Decay and Absorption			330	330	6.3
TOTAL	35311	328001	294959	658271	12658.9

Table 13

BIO-ASSAYS ANALYSES, 1960

Determinations for this period	Number of Samples	Highest Sample d/m/24 hours
Urine:		
Cs^{137}	9	4.9×10^3
Gα	1926	2.0
H^3	8	5.0×10^7
P^{32}	20	1.5×10^3
Pa^{233}	2	2.0
Po^{210}	2	1.1
Ra	7	6.2×10^3
Ru^{106}	3	23
Sr^{85}	3	21
Sr^{89}	357	3.3×10^5
Sr^{90}	625	6.2×10^3
TRE (Total Rare Earths)	493	5.0×10^4
U	501	13
Miscellaneous	47	--
Fecal:		
Gα	378	--
Sr^{89}	42	--
Sr^{90}	40	--
TRE	38	--
Others*	216	--

Summary:
Number of samples greater than 100 per cent of the limiting value -132
Number of times three successive samples exceeded 25 per cent of the limiting value - 67

* Analyses performed on specimens from employees of other installations.

Table 14

INSTRUMENTS ACQUIRED, 1960

Instrument Type	Quantity	Unit Cost	Total Cost
Cutie Pie, Nuclear Electronic	20	$ 276	$ 5,520
Cutie Pie, Victoreen Mod. 740	25	274	6,850
Eberline PAC-3G, α Counter	38	577	21,926
Linear Count Rate Meter, Q1511A-1R1	2	445	890
Victoreen Monometer II	6	252	1,512
Gelman Battery Operated Air Sampler	1	257	257
GMSM, Eberline Mod. 500A	6	607	3,642
GMSM, Eberline Mod. 500B	4	607	2,428
N_t Survey Meter, ORNL Q2004	3	1,075	3,225
DD2 Amplifier	1	463	463
Decade Scaler, Q1743-40R0	10	479	4,790
Eberline MAC, Alpha Sample Counter	2	7,222	14,444
Lab Monitor, Q2091-Beta	7	800	5,600
TOTAL	125		$71,547

Table 15

PORTABLE INSTRUMENTS ON ASSIGNMENT TO FIELD AREAS BY BUILDING NUMBER, 1960

Type	3001	3019	3026D	3026C	3038	3550	4500	7500	3517	9771	Total
Cutie Pie	58	35	10	21	35	27	69	23	14	18	310
Juno	8	1	1	3	-	2	11	2	-	8	36
GMSM	46	19	6	23	24	23	61	10	9	29	250
Samson	-	3	-	-	-	1	12	-	-	22	38
Dosimeter	21	38	12	29	25	22	33	5	53	42	280
PSA	4	-	-	1	1	2	6	-	-	1	15
Misc.	18	1	2	1	4	1	7	5	2	6	47
PGA	2	10	2	2	2	15	13	-	-	4	50

Table 16

CALIBRATIONS RESUME, 1960

Type Instrument	Total No. of Calibrations
Cutie Pie	1598
Juno	90
Samson	107
GM Survey Meter	1131
Dosimeters	429
Portable Scintillation, Alpha	31
Monitrons	188
Films	6539
Miscellaneous	183
PGA	271
TOTAL	10567

Table 17 Emergency Instruments, Clothing, and Other Equipment Procured and Installed in the Emergency Vehicle Assigned to the Calibration Unit

EQUIPMENT FOR CALIBRATION VEHICLE

A. Instruments

1	Alpha sample counter
1	Beta sample counter
1	Cutie Pie (regular)
2	Cutie Pies (1000 r/hr)
1	Cutie Pie (Long Tom)
2	Alpha survey meters (PAC 3G)
1	Dosimeter charge box
6	Dosimeters (200 mr)
6	Dosimeters (10 r)
1	Battery operated air sampler
1	Thermal neutron survey meter
2	Juno survey meters
3	GM survey meters

B. Clothing

6 prs.	Coveralls
4 prs.	Gloves (rubber)
12 prs.	Gloves (cotton)
4 prs.	Gloves (leather)
	Shoe covers
6	Lab coats
2	Raincoats
4	Hard hats

C. Other Equipment

Radio (Two way communications with X-10 Security Headquarters)

2	Safety goggles
2	Assault masks
1	Chemox mask
6	Urine sample kits
6 bxs.	Smear tabs

D. Miscellaneous Tags and Stationery Supplies

Stapler	Record books
Plastic bags	Tablets
Scissors	Clip boards
Masking tape	Paper towels
Wax string	Label-on tape
Danger Tags	Envelopes
Wax pencil	Glassine envelopes

III. REPORTS AND PAPERS

A. Papers

H. H. Abee, J. C. Hart, "A Proportional Liquid Effluent Sampler for Large Volume Flows", presented at AIHA Conference, Rochester, New York, April 28, 1960.

H. H. Abee, J. C. Ledbetter, D. M. Davis, E. D. Gupton, "Resume of Monitoring Activities at ORNL", presented at the Health Physics Division Annual Information Meeting, October, 1960.

B. Interdepartmental Reports

1. Weekly:

   (a) Radioactivity in Clinch River at ORGDP Water Filtration Plant

2. Monthly:

   (a) Summary of Bio-Assays Analysis

   (b) Radiochemical Analyses in White Oak Lake

   (c) Area Background Check

3. Quarterly:

   (a) Summary of Personnel Monitoring Data

   (b) Environmental Levels of Radioactivity from the Oak Ridge Area

   (c) Fall-out Data from ORNL Remote Monitoring Stations

Appendix I

Determination of Dose to the Left Hand of *** - P. R. No. ***

The dose to the surface of the left hand of the employee,[1] who performed a decontamination scavenging operation in Cell 11 of Building 3517 on March 8, 1960, has been determined experimentally to be approximately 5500 rad. While working in Cell 11, the employee had picked up contaminated scrap material consisting of sludge, bits of welding rods, and slag from electric arc cutting of stainless steel plates. The contaminated materials were scooped up by the left hand and transferred to a 1-gallon capacity "syrup" bucket.

Prior to this experimental study, some attempt was made to locate the bucket of material. However, upon investigation, it was learned that the bucket and its contents had been transferred soon after its removal from Cell 11 to the ORNL burial ground with subsequent loss of location and identity. In order to simulate conditions prevailing at the time that the employee performed his clean-up operations, it was necessary to obtain a similar source. The trough in Cell 12 was uncovered March 29. Fortunately, in this regard, the trough in Cell 12 is a continuation of the trough which leaves Cell 11; it was known that material from Cell 11 had been washed into Cell 12. Upon examination it appeared that the material in the Cell 12 trough was similar in appearance to that removed from Cell 11 by the employee. Using remote handling equipment, a significant quantity of the material from the trough in Cell 12 was obtained.

In order to determine the exposure, several approximations based upon available data were considered as follows:

(1) A dose rate reading taken with a "Fish Pole Probe" a few inches over the bucket which the employee handled on the day of the incident had been recorded as approximately 200 rad/hr; (2) the contaminated material contained radioactive

1. "The employee" has been substituted for the name of the person involved.

isotopes of which Ce^{144} - Pr^{144} were predominantly, if not exclusively, present; (3) the radioactivity was believed to be heterogeneously distributed in the scrap material; (4) the employee wore household type rubber gloves which have been shown to have an absorber thickness of approximately 30 mg/cm^2; (5) the total time spent by the employee in picking up the material was estimated by trial experiments with passive material to be six to nine minutes; (6) the radiation was almost exclusively beta as determined from the film badge worn by the employee; and (7) the material handled by the employee was the major source of radiation to the hand during his exposure.

In setting up the experiment, it was assumed that the bucket of material taken from the trough in Cell 12 was similar to the bucket of material scooped up by the employee. The bucket was identical with that used by the employee; the physical appearance of the material was similar; and a reading taken with a "Fish Pole Probe" indicated that the dose rate from the bucket of material used in the experiment was approximately the same as the dose rate reading obtained the day of the incident from the bucket used by the employee. A phantom hand was fashioned from paraffin; dosimetry films were placed at various depths in the phantom; and the phantom was covered in turn by a rubber glove of the type used by the employee. The loaded phantom was laid in contact with the top surface of the material in the bucket during the various exposure periods. (Had the "hand" been dipped through the material at various depths in the bucket, an estimate of the dose to the back of the hand might have been obtained. However, it was not considered advisable to run the "hand" through the contents of the bucket in this experiment because of the excessive exposure which would have been sustained by the experimenters. In addition, while scooping up the material with the "hand", the major exposure was considered to be to the palm and inside surfaces of the fingers.)

A depth dose curve based on the film measurements is shown in Fig. 12 and the probable dose to the surface of the hand by this method is estimated to be approximately 5500 rad.

With the available data it is possible also to estimate the dose by calculation. Assume that the energy flux over the surface of the source (a 20 cm diameter disc) is uniform and is reduced only by absorption in the 50 cm of intervening air; assume further that the energy flux is uniformly distributed over a hemisphere of radius 50 cm at the distance of the film badge. (The HVL for the radiation is 150 mg/cm^2.) Then the energy flux at the badge, ϕ_B, is related to the energy flux at the surface of the source, ϕ_S, by the equation;

$$\frac{f\phi_B}{\phi_S} = \frac{\pi(10\ \text{cm})^2\ (\text{disc})}{2\pi(50\ \text{cm})^2\ (\text{hemisphere})} \qquad (1)$$

where f is the factor for increasing ϕ_B to be equivalent to zero absorption by air. Using the density of air at 21°C as 1.2 g/l, a 50 cm layer is found to give f the value 1.33.

Then: $$\phi_S = \frac{2(2500)\ (1.33)\ \phi_B}{100} = 67.5\ \phi_B \qquad (2)$$

If air absorption is neglected as in (2) above, the dose rate should be proportional to the flux. Therefore, the dose at the surface of the badge, D_B, may be related to the dose at the surface of the source, D_S, according to the equation:

$$D_S = 67.5\ D_B \qquad (3)$$

Since the dose at the surface of the badge was 100 rad, one calculates

$$D_S = (67.5)\ (100\ \text{rad}) = 6750\ \text{rad} \qquad (4)$$

The dose at the surface of the hand D_H through the rubber glove can be shown as

$$D_H = D_S \times \text{factor of reduction by glove} \qquad (5)$$

or

$$D_H = 6750 \left(\frac{5500}{6400}\right), \qquad (6)$$

where $\frac{5500}{6400}$ is the experimental ratio of the dose at the surface of the glove to the dose at the surface of the hand, and

$$D_H = 5800 \text{ rad} \qquad (7)$$

The calculation in (7) above agrees reasonably well with the value of 5500 rad obtained from the curve (Fig. 12) drawn from the experiment.

(s) D. M. Davis

(s) E. D. Gupton

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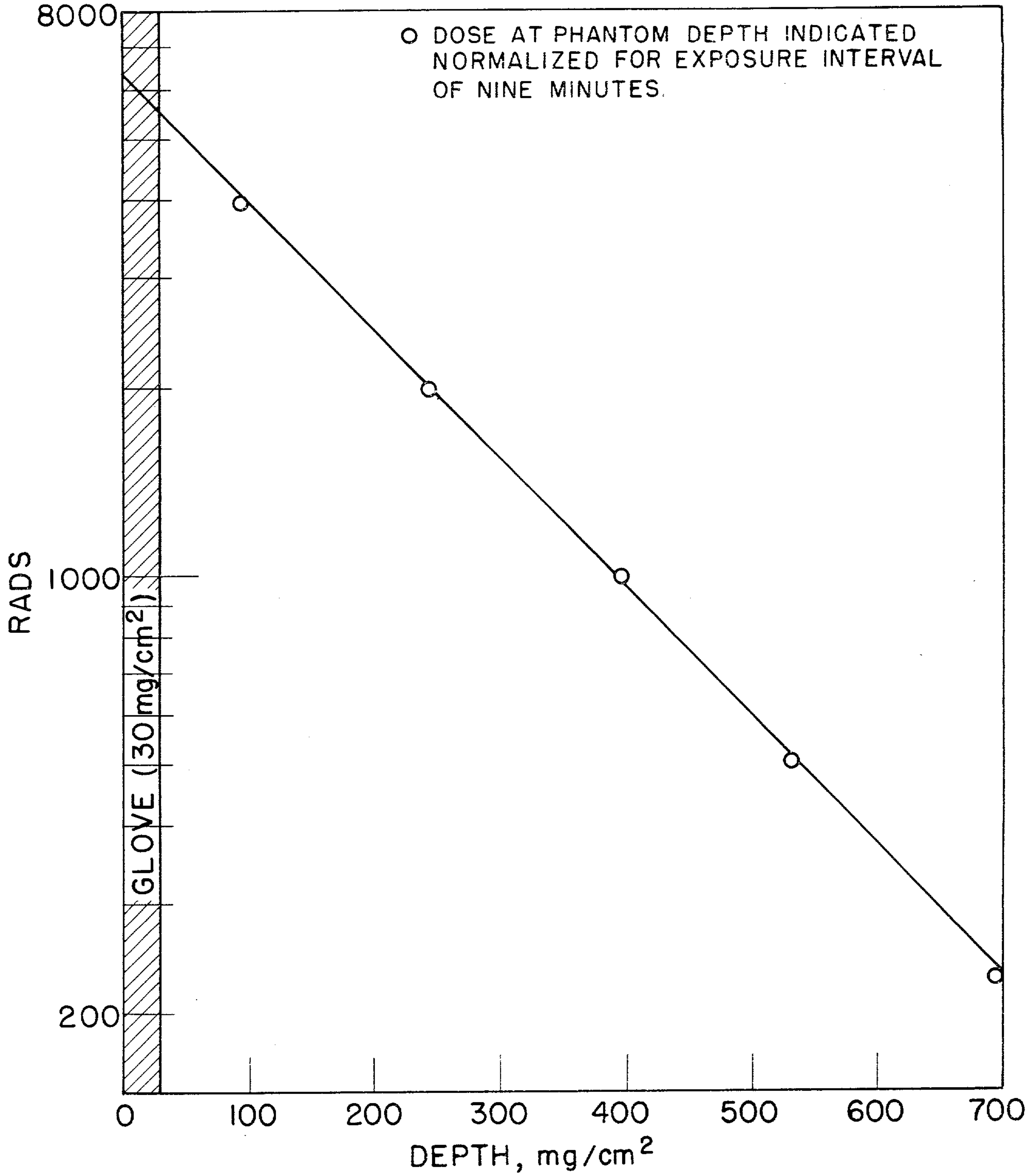

Fig. 12. Estimated Depth Dose to Palm of Hand of F.P.P.P. Employee.

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